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AGRICULTURAL MEMORANDUM NO 416

Heading dates of S24 perennial ryegrass and spring temperatures

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Introduction Cooper (1952) and Beddows (1968) have shown that the year to year and site to site variability in the heading dates (spaced plants) of S24 perennial ryegrass can be related to spring temperatures. In their studies they used accumulated day degrees above 42°F (5.6°C) for the months of March and April i.e. air temperatures. Additionally Beddows considered soil temperatures expressed as the number of days in March on which the 0900 GMT observation of soil temperature at 10 cm depth under bare soil exceeded 5.6°C. In general the observed dates of 50% ear emergence in a grass sward are very similar to those obtained with spaced plants. When the available data at a number of sites for the years 1962 to 1970 were analysed by similar methods to those used by Cooper and Beddows it was found that there was a tendency for the same heading dates to be associated with lower totals of accumulated day degrees at the western sites as compared with the eastern ones. This suggested that mean soil temperatures might give a closer relationship with heading dates than did the air temperatures. The earth temperature at 30 cm under short grass has a relatively small diurnal variation (about 1 to 2°C in spring) and a single daily observation can provide in most soils a good estimate of the mean soil temperature just below the ground surface.

Relationships between heading dates (spaced plants) and some functions of spring temperatures.

Data For spaced plants heading dates of S24 perennial ryegrass were available for the years 1950 to 1969 at the Welsh Plant Breeding Station at Aberystwyth and at the National Institute of Agricultural Botany at Cambridge. Mean air temperatures and totals of accumulated day degrees could be obtained from the standard meteorological observations at both sites, but 30 cm earth temperatures were not recorded. The 10 cm temperature under bare soil is only measured at 0900 GMT when it is close to its minimum value and it has a large diurnal variation which depends on the thermal properties of the soil and the time of year. For Cambridge mean monthly earth temperatures at 30 cm depth measured at the Botanic Garden site were used. The most suitable nearby site to the Welsh Plant Breeding Station was at Trawscoed, but unfortunately the earth thermometer was probably providing systematically low readings up to October 1965 when it was replaced. In order to provide estimates of the mean monthly earth temperatures before that date the observations at Swansea have been used. Corrections of -0.3°C to March temperatures and -1.5°C to April temperatures were applied based on the mean Swansea - Trawscoed differences during the period 1966 to 1970. The justification for the use of such data lies in the results described later in this memorandum, but in general a high correlation is observed between temperatures at sites along the Welsh coast.

Heading dates and accumulated day degrees. Figure 1 shows a plot of the heading dates against accumulated day degrees for the months of March + April and it can be seen that there is a very considerable scatter of points.

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Heading dates and air temperatures. In figure 2 the heading dates were plotted against the sum of the March and April mean air temperatures. (If this is divided by two it gives an approximate value for the mean air temperature during these months). Here there was a general relationship between low temperatures and late heading, and high temperatures and early heading but the scatter of points was still quite large. Additionally the same mean temperatures appeared to be associated with earlier heading at Aberystwyth than at Cambridge.

Heading dates and 30 cm earth temperatures. From figure 3 it can be seen that much of the year to year variability in heading dates can be accounted for by a consideration of the mean 30 cm earth temperature during March and April. Since neither set of temperature readings was actually made at the experimental site the true values may be on average slightly lower or higher than those used in the graph.

In order to obtain a linear relationship it was necessary to consider a function expressing the mean rate of floral development. Since floral initiation in S24 occurs in early March this was taken as

$$Y = \frac{1}{D} \text{ day}^{-1}$$ where D was the number of days after the 28th February to the heading date.

Figure 4 shows the resulting graph together with the regression lines for Cambridge and Aberystwyth. At Cambridge the 1968 heading date did not fit the general pattern and when it was removed from the analysis the variance accounted for increased from 64% to 81%.

Excluding the 1968 heading date at Cambridge the resulting regressions were:

$$Y = 10^{-2} (0.611 + 0.104X) \pm 0.00053 \text{ for Aberystwyth}$$

$$Y = 10^{-2} (0.679 + 0.093X) \pm 0.00041 \text{ for Cambridge}$$

where X was the mean earth temperature at 30 cm for the period March plus April. The variance accounted for was 81% at both sites. There was no significant difference between the slopes or intercepts of these lines and the overall regression was

$$Y = 10^{-2} (0.634 + 0.1003X) \pm 0.00047 \text{ day}^{-1}$$

It is interesting to note that the rate of development of the flowering shoot appears to increase linearly with increasing mean earth temperatures. Since the constant term is positive the regression predicts some development even at zero (°C) temperatures. However as there are no experimental data covering that part of the temperature range it is not justifiable to extrapolate the results to such values. As only monthly mean temperatures were readily available it has not been possible so far to compare the rate of development with mean temperatures up to the observed date of heading.

Although 0900 GMT observations of soil temperatures under bare soil are less satisfactory than the earth temperatures under grass it may be possible to use them to deduce the mean monthly soil temperatures. At Hurley the March soil temperature is on average 1.1°C below the earth temperature while in April it is 0.5°C lower. However, such differences are likely to vary in different soils.

Ear emergence dates 1962-1970 and mean earth temperatures.

Some of the heading dates (50% ear emergence) could be compared with the predicted dates obtained using the calculated regressions and the mean earth temperature at some suitable meteorological station. These have been summarised in table 1, using the overall regression equation. Considering that May temperatures were not taken into account, agreement with observation was generally reasonable for the sites in central and southern England and in Wales. In 1970 May was a notably warm and sunny month in the south of the British Isles. The absence of warm early springs (excepting 1966 and 1967 at Seale Hayne) during this period is very striking.

At the two Scottish sites differences between the observed and calculated dates were very large, mainly due to the effects of May temperatures. In 1967, 1968 and 1969 exceptionally low temperatures occurred in the north during May. The Aberdeen heading dates were, however, generally earlier than one would expect from a consideration of the observed earth (or air) temperatures. This may be an effect of daylength as by the end of April it is 15 hours 30 minutes at Aberdeen but only 14 hours 50 minutes at Cambridge.

Forecasting heading dates

The importance of earth temperatures in determining the heading dates of S24 perennial ryegrass suggested that use might be made of the observed mean March earth temperature to make a prediction of the earliness or lateness of heading in a given year. Considering the years 1952 to 1969 the Cambridge heading dates and mean March earth temperatures were each divided into three categories: early, average and late. Each category contained 6 years. The divisions were:

	Late (L)	(Average (A)	Early (E)
temperature	less than 5.1°C	5.1°C to 6.4°C	greater than 6.4°C
Heading	after 15 May	10 May to 15 May	before 10 May

The resulting contingency table gave:

		HEADING DATE		
		E	A	L
MARCH	E	5	1	0
EARTH	A	1	3	2
TEMPERATURE	L	0	2	4

$\chi^2 = 12$ with 4 degrees of freedom. This was significant at the 2% level.

Using the same definitions of early, average and late years a similar contingency table was constructed for Aberystwyth.

This gave:

		HEADING DATE		
		E	A	L
MARCH	E	7	3	0
EARTH	A	0	3	2
TEMPERATURE	L	0	0	3

$\chi^2 = 16.7$ with 4 degrees of freedom. This was significant at the 0.2% level.

At Aberystwyth the Cambridge definitions of earliness and lateness gave a much greater number of years in the former category.

Thus for sites in central and southern England or in Wales at heights above sea-level of less than about 200m it is possible to use the March earth temperature to make a useful prediction of the earliness or lateness of the heading date of S24 or other early-heading perennial ryegrasses. If the March temperature is greater than 6.4°C heading will probably occur before the 11th of May. If it exceeds 7.5°C heading will usually occur before the 7th May.

As far as late years are concerned warm weather in late April and May can lead to somewhat earlier heading than might otherwise be expected but if the mean earth temperature in March is less than 5°C heading will occur after the middle of May, except at some sites in years such as 1970 when early May was unusually warm.

At the end of April the calculated regressions may be used in these areas to calculate the expected heading dates using the March and April mean earth temperatures. At the moment it is not possible to provide any predictive rules for the north of England or Scotland.

References

Beddows, A.R. 1968 J. Br. Grassld Soc. Vol. 23 No. 1 pp 88-97

Cooper, J.P. 1952 J. Ecol. Vol. 40 pp 352-379

Any comments or criticism on this paper should be referred to the Author.

Meteorological Office
Bracknell, Berks.

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Table 1

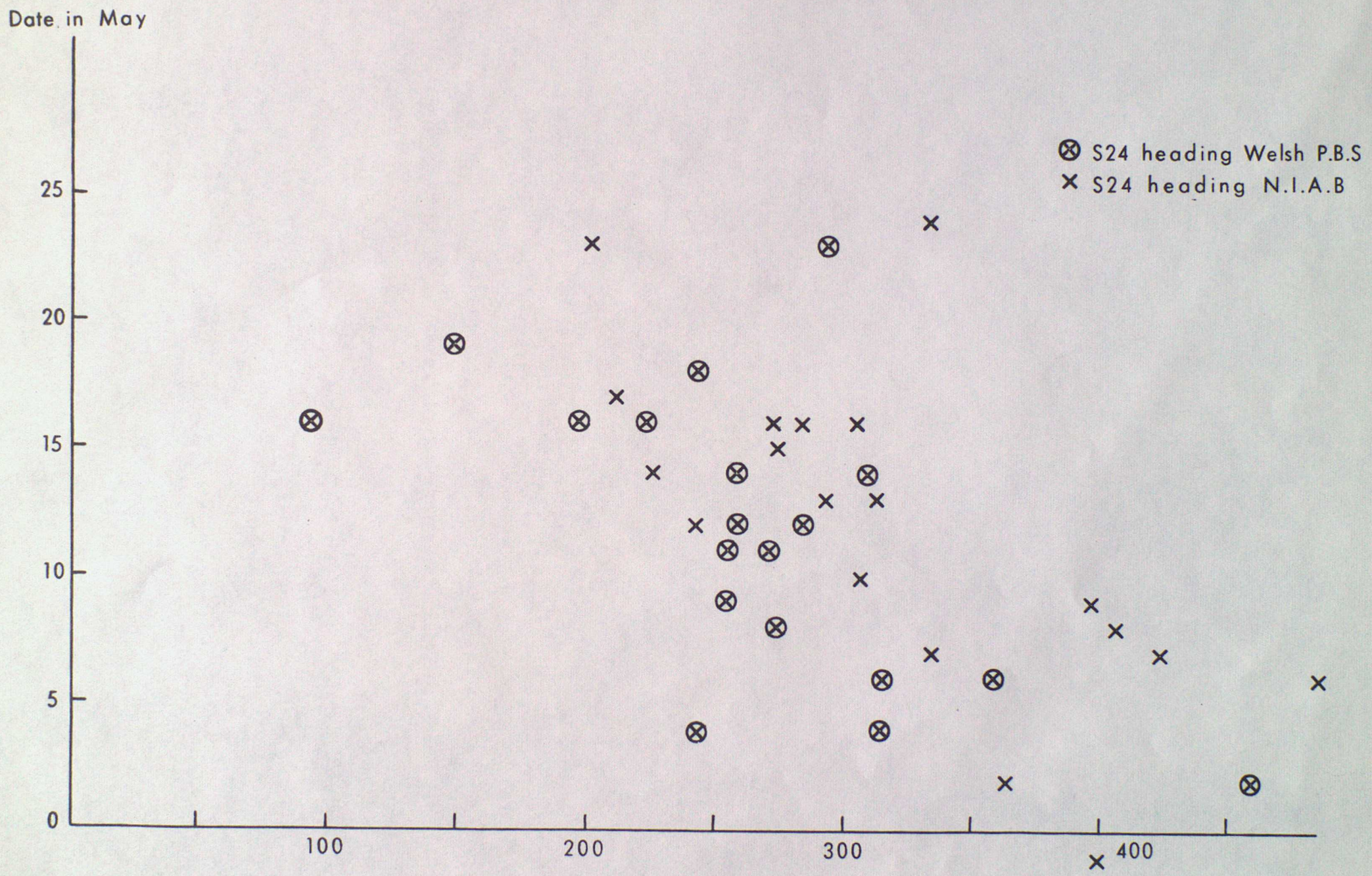
Mean (March + April) 30 cm earth temperatures and calculated and observed dates of 50% ear emergence of S24 perennial ryegrass.

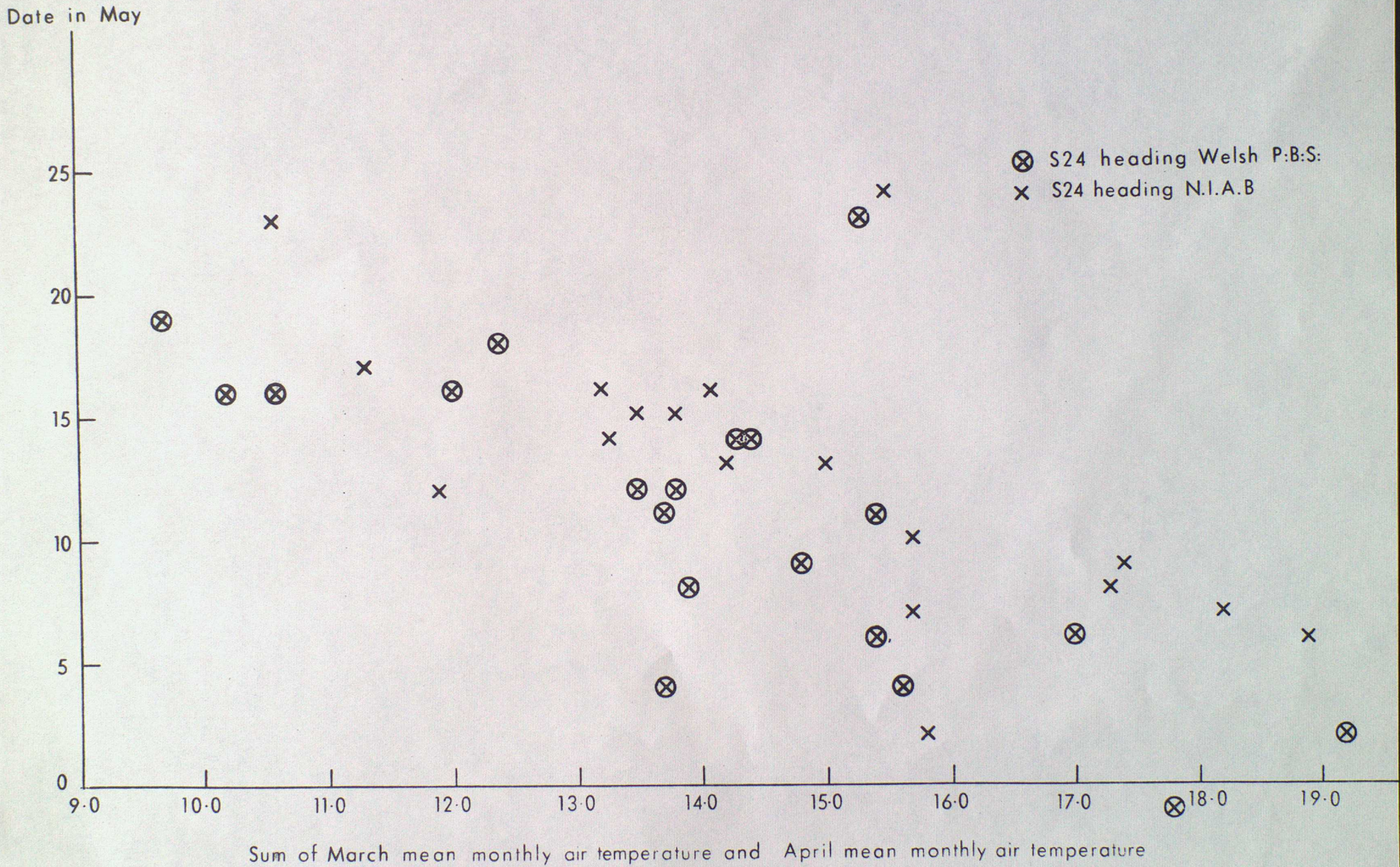
Year	Totnes temperature	calculated heading date	Seale Hayne observed heading date	Trawscoed temperature	calculated heading date	Trawscoed observed heading date
1962				6.15 *	19/5	19/5
1963	7.45	11/5	20/5	6.35 *	18/5	22/5
1964	7.80	9/5	14/5	7.50 *	11/5	12/5
1965	7.50	11/5	13/5	7.35 *	12/5	14/5
1966	8.60	5/5	5/5	7.50	11/5	11/5
1967	8.40	6/5	7/5	7.85	9/5	11/5
1968	7.60	10/5	13/5	6.95	14/5	11/5
1969	6.95	14/5	14/5	6.35	18/5	13/5
1970	6.75	15/5	15/5	6.25	19/5	13/5

Year	Hurley temperature	calculated heading date	Hurley observed heading date	Cambridge temperature	calculated heading date	Cambridge observed heading date
1962	5.40	25/5	21/5	5.80	22/5	21/5
1963	6.15	19/5	22/5	6.25	18/5	21/5
1964	6.35	18/5	17/5	6.75	15/5	15/5
1965	6.65	16/5	15/5	7.05	13/5	12/5
1966	7.20	13/5	14/5	7.00	14/5	13/5
1967	7.35	12/5	16/5	7.60	10/5	10/5
1968	6.75	15/5	18/5	7.40	12/5	7/5
1969	6.00	20/5	21/5	6.20	19/5	15/5
1970	5.70	22/5	19/5	5.65	23/5	13/5

Year	Craibstone temperature	calculated heading date	Aberdeen observed heading date	Auchincruive temperature	calculated heading date	Auchincruive observed heading date
1962	3.70	8/6	25/5			
1963	4.45	1/6	27/5			
1964	5.70	27/5	13/5			
1965	4.80	29/5	20/5			
1966	4.30	3/6	28/5	6.05	20/5	27/5
1967	5.30	25/5	30/5	6.30	18/5	29/5
1968	4.80	29/5	1/6	5.95	20/5	27/5
1969	3.70	8/6	8/6	4.70	30/5	28/5
1970	3.75	8/6	30/5	5.00	28/5	25/5
1971	5.35	25/5	17/5	6.75	15/5	18/5

* using Swansea to estimate Trawscoed


Date in May
25
20
15
10
5
0
100
200
300
400
March and April accumulated day degrees
S24 heading Welsh P.B.S
S24 heading N.I.A.B


Date in May
25
20
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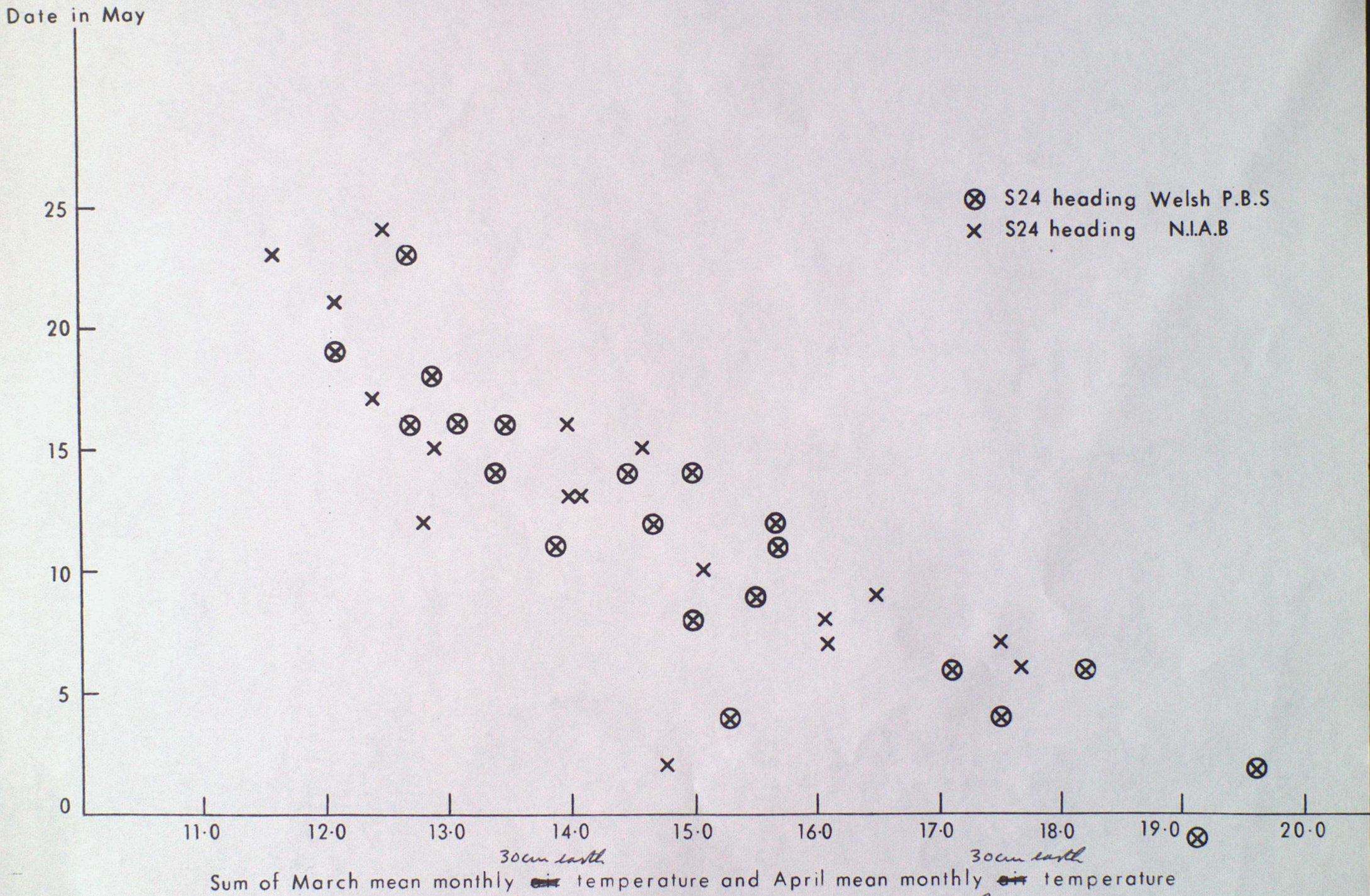
15·0
16·0
17·0
18·0
19·0
S24 heading Welsh P:B:S:
S24 heading N.I.A.B
Sum of March mean monthly air temperature and April mean monthly air temperature


Date in May
25
20
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13·0
14·0
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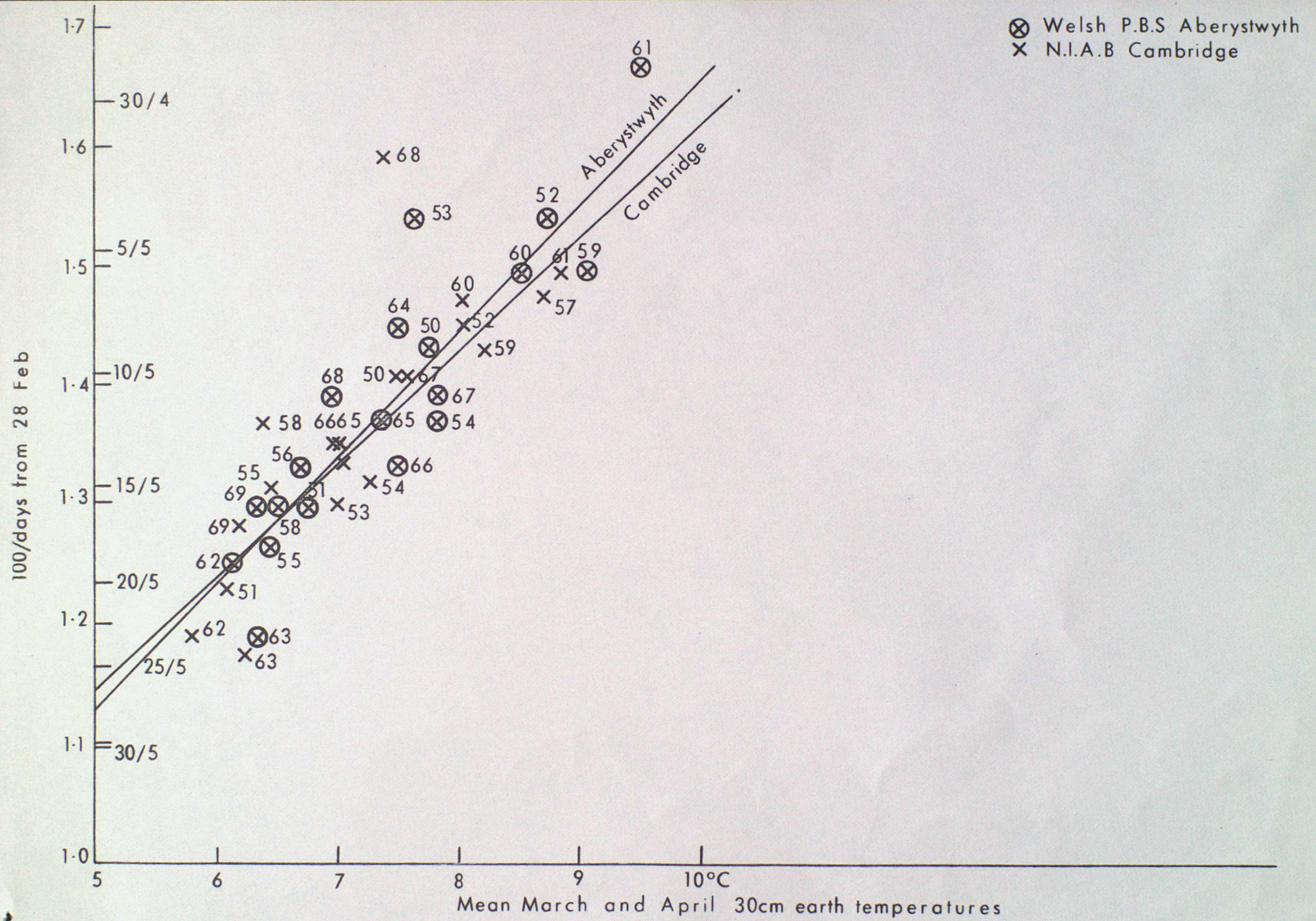
17·0
18·0
19·0
20·0
S24 heading Welsh P.B.S
S24 heading N.I.A.B
30cm earth
30cm earth
Sum of March mean monthly air temperature and April mean monthly air temperature


Welsh P.B.S Aberystwyth
N.I.A.B Cambridge
Aberystwyth
Cambridge
100/days from 28 Feb
1·7
30/4
1·6
5/5
1·5
10/5
1·4
15/5
1·3
20/5
1·2
30/5
1·1
1·0
25/5
5
6
7
8
9
10°C
Mean March and April 30cm earth temperatures